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DENSE STANDS OF REPRODUCTION

AND

STUNTED INDIVIDUAL SEEDLINGS OF LONGLEAF PINE

By

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* - This series of publications releases data gathered in connection with investigations being carried on at the Southern Station. The information contained in them is subject to correction or amplification following further investigation. - Editor

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Factors affecting early dominance

The importance of density as a factor in the growth of forest stands is universally recognized by foresters. In their consideration of forest reproduction they are rightly concerned with total coverage or stocking of openings, rather than in the possibility of having too many seedlings. This is because thin spots or blank spaces in the new stand often fill in too slowly, if at all, or with inferior species. Thick spots normally take care of themselves promptly through natural thinning. However, this is not always true.

The silvics of longleaf pine is interesting because of the numerous peculiarities of the species. Some of these are fairly well recognized by foresters, as for example a remarkable resistance to fire (and some insects), a special susceptibility to injury by hogs and brown-spot disease, the infrequent seeding, and the delayed height growth.

Less obvious and less well known are an extreme nanism following thick seeding or resulting from sterile soil; the longevity of puny, stunted seedlings; and an expression of dominance, delayed at first but prominent later. An early expression of dominance simply means an early victory for the majority of those trees which will be in the final stand. Deen[1] lists seven factors which promote or retard an early expression of dominance in white pine as follows: (1) Inherent characteristics, (2) size and origin of seed, (3) site, (4) variation in age, (5) density, (6) disease or insects, and (7) treatment. In a crowded stand where competition is keen, various causes may contribute to the elimination of certain individuals. As pointed out by Hauch,[2] emphasizing genetic differences, some seedlings are weak from the start (1 and 2), some are handicapped early by small size (3 and 4), and still others are retarded by later injuries (6 and 7). Particularly in even-aged stands, any material retardation of this competitive process ("survival of the fittest") is an undesirable addition to length of the rotaton for forest crops. In seeking a measure of dominance, Deen points to the standard deviation of diameter, and notes that it increases as the average diameter of a stand increases and as the density of a stand decreases.

[1] Deen, J. Lee. Some aspects of an early expression of dominance. Bul. 36, Yale University, New Haven, Conn., 1933.

[2] Hauch, L. A. Deviation capacity of forest trees. Jor. of For. XXXII (7): 729-733. 1934.

Working with Douglas fir, Meyer[3] also has studied variation in the diameters of even-aged stands. His primary interest appeared to be in mathematical relationships rather than in biological causes, but he recognized three of the seven factors (3, 4, and 5) later listed by Deen.

Stunted longleaf pine seedlings

That longleaf pine seedlings are slow in starting height growth is well known. That they often persist many years without any appreciable development is not as widely recognized. Severe cases of stunting are now attributed to the ravages of fire, brown-spot disease, or both. The dwarfed seedlings have two distinct forms as shown in plate 1.

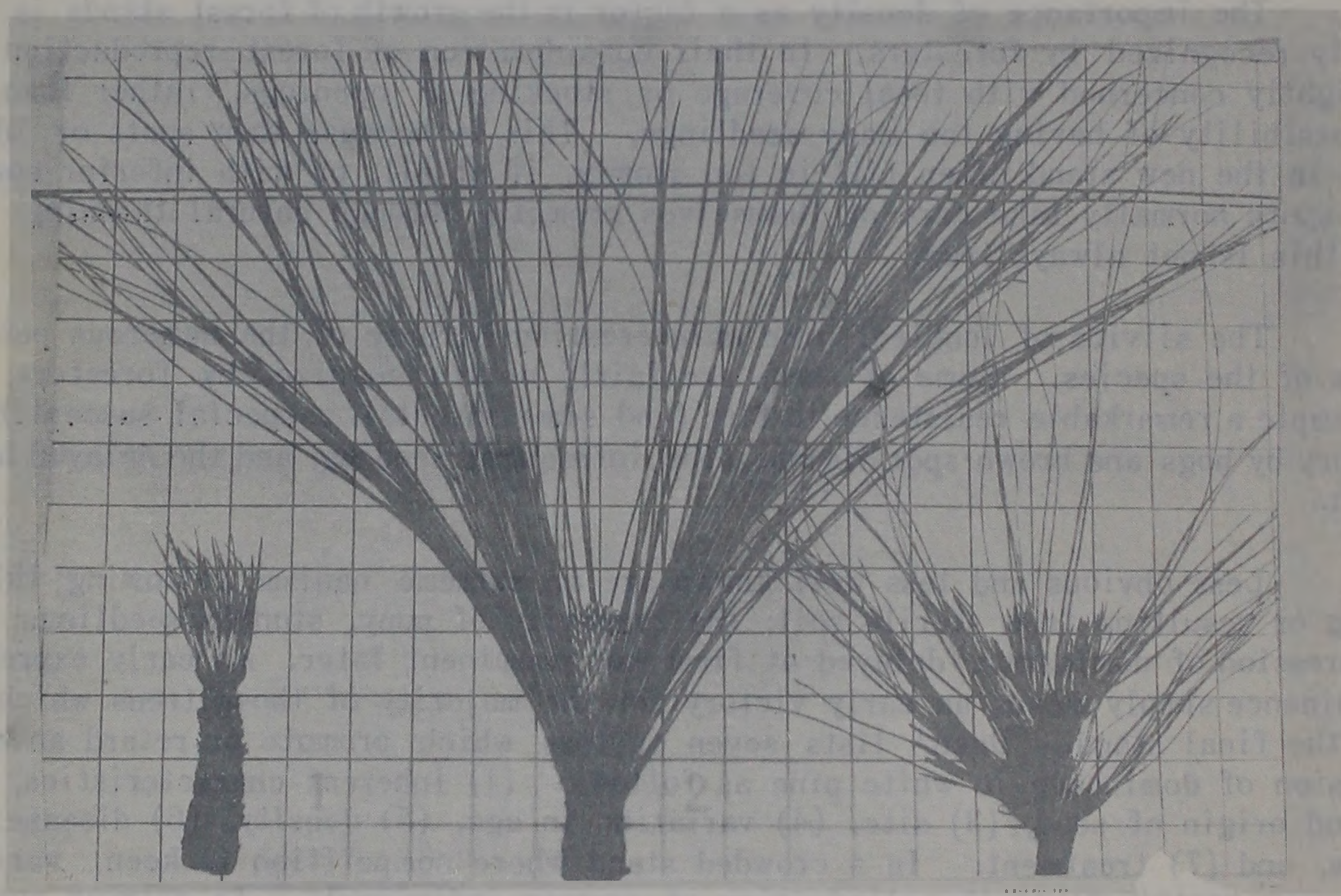

Plate 1

Type of longleaf pine seedlings:

1. Stunted, no bud injury, conical stem.
2. Normal, growing bud, cylindrical stem.
3. Stunted, adventitious swellings, gnarled top.

[3] Meyer, W. H. Diameter distribution series in even-aged stands. Bul. 28, Yale University, New Haven, Conn. 1930.

A roughly conical form of stem, but with a blunt bud, is shown at the left. This is a common form for a badly suppressed seedling. The sharp taper indicates weak and failing terminal growth. Just the opposite in stem form is exhibited by the stunted seedling shown at the right. The gnarled and swollen top tapers downward to the ground line. This is a common form for seedlings that have been repeatedly and frequently injured. Brown-spot disease as well as fire may cause this deformity. The runts on either side in this picture may be contrasted with the normal development of the seedling in the center. It has started a vigorous new shoot which has about the same diameter as the old stem, thus giving the whole a cylindrical appearance. The dormant bud of such a seedling is white and sharp-pointed.

Close observation of peculiarities in foliage of stunted seedlings was made by Ellison [4] working at Bogalusa, La., in 1932. He found the smaller, shorter seedlings had less foliage and were more likely to have only two needles to a fascicle. A recurrence of primordial leaf forms is also common on small seedlings stunted because of disease or other injury.

The length of time that badly dwarfed long leaf pine seedlings can remain alive is not precisely known. Near the present experimental plots at Bogalusa no counts were made in 1921, but germination on the freshly burned surface must have been very dense as about 200,000 seedlings per acre were still there at the end of 8 years. Ten years elapsed before a full stand of crop trees emerged from the grass. Of the seedlings which germinated at the rate of 14,000 to 16,000 per acre at McNeill, Miss., in 1924, less than 5 percent now survive, except where they were protected from both fire and grazing. There, 45 percent are still alive. However, the survivors are less than 1 inch in diameter and less than 2 inches high. See plate 2. Now at 10 years of age they are all runts, even those in large open spaces. Professor H. H. Chapman thinks they will pass out of the picture between the tenth and fifteenth year. When these seedlings were 8½ years old, over 1,000 of them were carefully measured. The average heights and ground diameters of the stems are shown by the following triangles sketched to actual size.

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[4] Ellison, Lincoln. Notes on the occurrence of diphyllody in longleaf pine seedlings. Unpublished Manuscript RS-SS, M-1, Pines, Mr (Ecology). March 20, 1933.

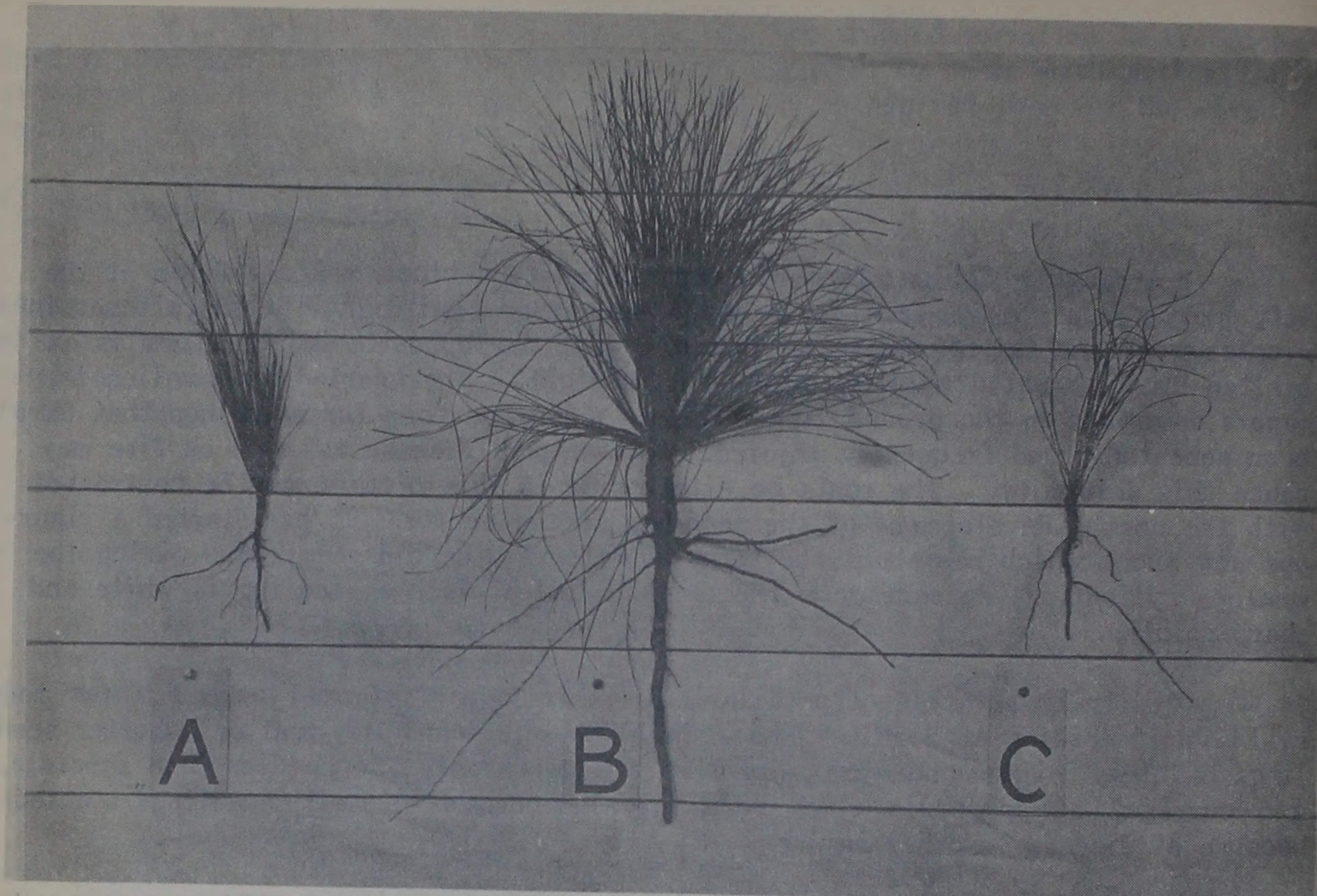


Plate 2

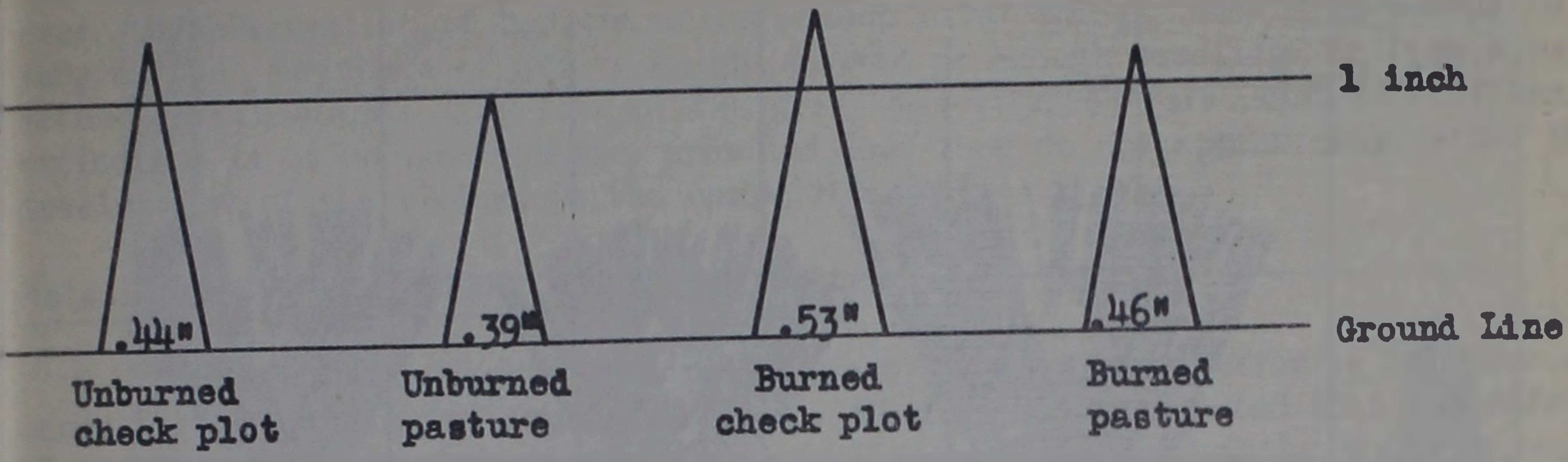
Longleaf pine seedlings from the grazing and burning experimental area at McNeill, Miss.

A. Typical of annually burned plot (ungrazed); diameter less than 1/2-inch; age 9 years.

B. Normal seedling from irregularly burned area; active height growth about to start; age unknown.

C. Typical of unburned plot (ungrazed); affected by brown-spot disease; similar to seedling A in stem development; age 9 years.

NOTE: Lines on chart are 6 inches apart. Lower ends of roots are broken off.



The importance of natural site factors is indicated by the fact that a very similar degree of development was attained by longleaf pine reproduction at Urania, La., in 4 years' less time. There the seedlings were less affected by brown spot and fire and stood in moister soil. What happens on relatively dry and poor sandy soils is indicated by long-time records taken on the Choctawhatchee National Forest in western Florida. There longleaf pine seedlings have withstood fire, brown spot, and the competition of other vegetation. About 8 percent of them survived at the end of ten years. Many of these survivors, 13 years old in the fall of 1933 (i.e., from the seed crop of 1920), are still in the grass stage and show no signs of shooting up. The seedlings now starting to grow in height are thought to be 20 years old, originating from the seed crop of 1913, but the actual age is unknown.

The impossibility of determining age by the microscopic examination of cross-sections of the stem has been shown by Pessin[5]. This greatly handicaps the study of seedling development by forcing investigators to depend almost solely upon long-drawn-out observation of permanent sample plots for exact information. A practical method of predicting when a stand of longleaf pine in the grass stage will begin active height growth would be very useful to foresters. With this end in view records are now being kept on seedlings of known age, to show changes in bud development. There are two very distinct types of buds to be found on dwarfed seedlings. See numbers 2 and 4 of plate 3.

[5] Pessin, L. J. Annual ring formation in Pinus palustris seedlings. Am. Jor. Bot., 21: 509-603, illus. 1934.

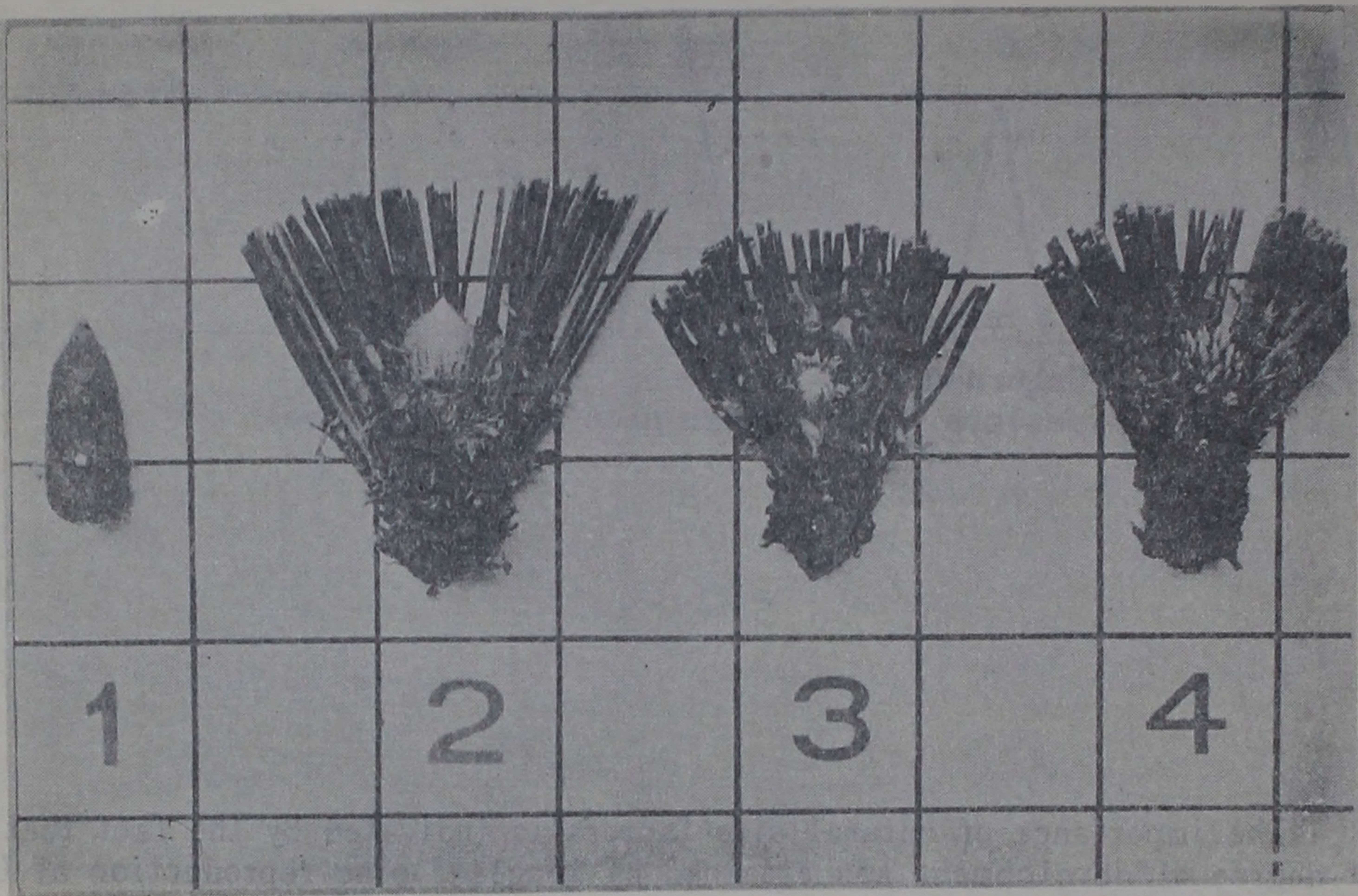


Plate 3

from
Types of buds [redacted] longleaf pine seedlings:

from
1. Normal bud [redacted] seedling making rapid height growth.
2. Well-formed, pointed bud from vigorous seedling still in the grass stage.
3. Amorphous, weak bud, probably intermediate between types 2 and 4.
4. Flat bud not indicative of stem growth and producing only a cluster of foliage.

Needles have been trimmed aud parted to show buds.

The dormant buds of seedlings about to make active height growth are invariably white and pointed. The reverse statement seems less dependable. However, the observation of bud character, among other things, should be useful in judging the imminence of active height growth in enough seedlings to form a new second-growth stand. The fate of the great majority that are doomed to ultimate extinction is of no consequence, provided that they do not appreciably retard the development of the victors in the competition.

Relation between dominant and dominated seedlings

In thinning sapling and pole stands a very common error is to incur expense for the cutting of supressed trees. Studies have indicated that the effect of such trees on the rate of growth in the dominant portion of the stand is negligible. However, in young well-stocked even-aged stands the death of suppressed trees naturally proceeds slowly for tolerant species. In consequence the individually feeble, suppressed trees may possibly form an understory stand dense enough and persistent enough to have a perceptible effect on the dominant stand.

To test this hypothesis a study was made near Bogalusa, La., in March, 1934. Heavy natural seeding on a burned surface in 1920 resulted in an overdense stand of seedlings. A small percentage of them, hardly enough for a full stand, had started height growth 10 years later. Results as a whole appeared better on the least densely seeded areas. For the test, two dozen actively growing seedlings from 1 to 6 feet tall (four in each 1-foot height class) were chosen at random, except that care was taken to avoid all active competition within 6 feet on any side. In other words no seedlings were used which were subject to close competition from any other actively growing pines or from oak brush. Each selected seedling was surrounded by a stand of longleaf pines in the grass stage only. Circles with a radius of 2.63 feet were scribed on the ground using the selected seedlings as centers. This established 24 temporary half-milacre plots each with a single central dominant surrounded by a unknown number of stunted competitors [6]. The height of growing seedlings was measured in feet and tenths. The stunted seedlings were counted and diameters measured with beam calipers in tenths of inches. The figures, averaged by heights of dominants, are shown on an acre or milacre basis in Table 1, and figures 1 and 2.

Each increase of one foot in total height of a leading or centrally dominant seedling was found to be accompanied by an average decrease of 20 seedlings or of 6 square inches of basal area in the surrounding stand; that is, on a half-milacre plot. Radius of a circular 0.0005-acre is 2.63 feet. (Basis - 24 half-milacre plots.)

[6] Center trees over 6½ feet high were not included because in all probability their age and size had already caused accelerated mortality among the dwarfed seedlings close to them. Thus the eventual and inevitable victory of the dominant over the dominated (if included in the test) might easily destroy evidence of earlier mass effect of the runts in retarding the leaders. Center trees under 6 inches tall were avoided because their dominance is more likely to be temporary.

FIGURE 2

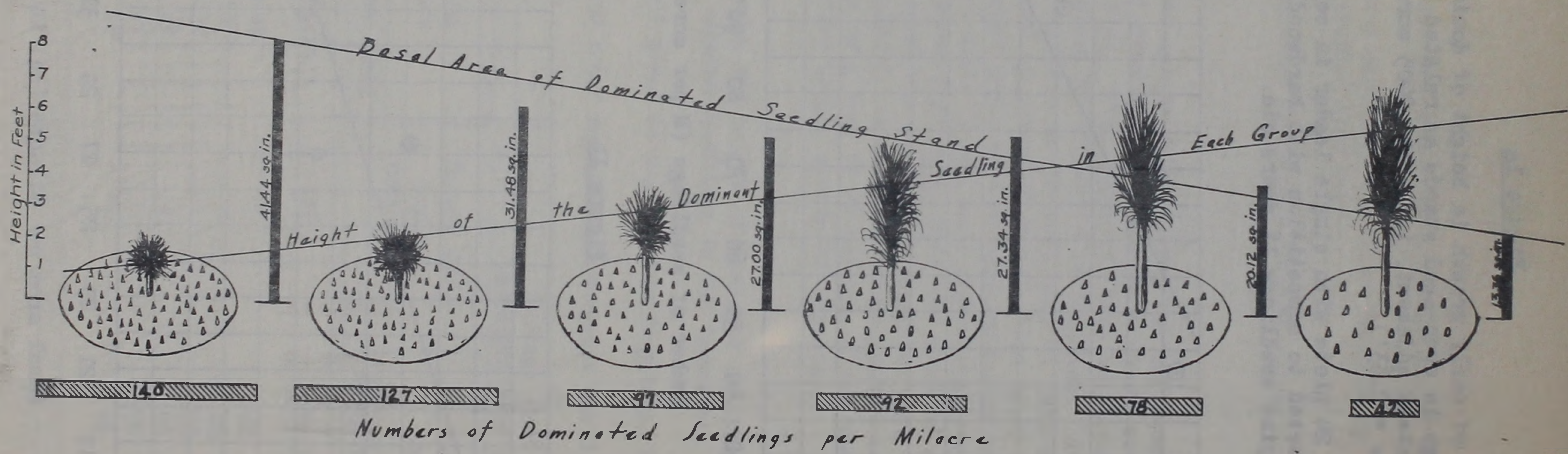
AMOUNT OF EARLY HEIGHT GROWTH OF DOMINANT LONGLEAF PINE SEEDLINGS IN EVEN-AGED STANDS

AS RELATED TO DENSITY OF SEEDLING STAND IMMEDIATELY ADJACENT; i.e., ON HALF MILACRE PLOTS. RADIUS = 2.63 FEET

Basis: 24 plots with single leader in center of each and not subjected to competition of hardwoods or larger pines

All pine seedlings-13 years old

Bogalusa, La., March, 1934



Note: Brown spot infection 12-20-23 = 37%
Dates of Burning: Sept., 1920; Mar., 1928; Feb., 1932; Feb., 1934.

The extreme difference in density of seedling stands on the Bogalusa plots here reported is 70 percent. If evidence from McNeill is used to interpret this, only about 15 percent appears due to killing of runts by the dominant seedlings. The bulk of the difference appears ascribable to the reverse relationship (No. 1 above); that is, where the density of stand is reflected in the growth of dominants. In other words, in an even-aged stand of longleaf pine seedlings, high densities in the dwarfed portion appear to retard the early growth of dominant seedlings, and during the first 10 to 15 years at least, this effect is more prominent than the killing of suppressed seedlings by dominant seedlings.

A severe infection or epidemic of brown spot disease in an unburned area, or fire itself in an annually burned area, are both stunting agents in their cumulative effects on longleaf seedlings in the grass stage. Both agents effect these small dominant and dominated seedlings in different degrees, but there is some indication that the net effect of the agents is opposite. Apparently this is because the larger seedlings are the more susceptible to severe infection, thus giving the disease a "leveling" effect, whereas annual winter burning injures the smaller puny seedlings more than the larger ones. However, the mathematical evidence of this at McNeill is weak, as the standard deviation of ground diameters of seedlings in the grass stage at McNeill was found to be 0.12 inch, or 25 percent of the mean, on the unburned area where disease was heavy, and nearly the same, 0.14 inch, or 26 percent of the mean, for the annually burned area. Thus further evidence is needed to show definitely whether or not the exclusion of fire retards and annual burning promotes the early expression of dominance. A detailed discussion of silvicultural burning or other cultural methods of hastening seedling dominance is beyond the scope of this paper.

Use of ground diameters in recognizing imminent height growth

Whether or not practical forestry measures for promoting an early expression of dominance can be found, a means of predicting the rate of development of established stands of longleaf pine in the grass stage would be useful. Conditions of site, disease, fire, and present stage of development will enter into any such predictions. As an index of the present stage of development, the diameters of seedlings at the ground line should be considered.

Figure 3 indicates that at Bogalusa these diameters, at age 13, form a fairly normal frequency distribution around a mean of 0.56 inches, the most common size (mode) being 1/2-inch. This chart gives a graphic picture of only the stunted portion of the stand. Unquestionably nearly all crop trees will develop from within or beyond the skewed right-hand extremity of this curve. There are already more than enough trees over one inch in diameter at the ground line to form a fully stocked final stand. The trees for this stand all fall above the most common rejection limit used in statistical studies. Thus the mean diameter, 0.56 inch, plus three times the standard deviation (0.19 inch), or 0.57 inch, equals 1.13 inches. In other words as soon as dominance has been expressed to the extent of designating a full stand of crop trees, as it has at Bogalusa, these trees properly belong in a separate class or distinct "universe" for statistical study. The line between the growing and the stagnating portions of such a natural stand may be drawn arbitrarily, but one inch in diameter at the ground is suggested.

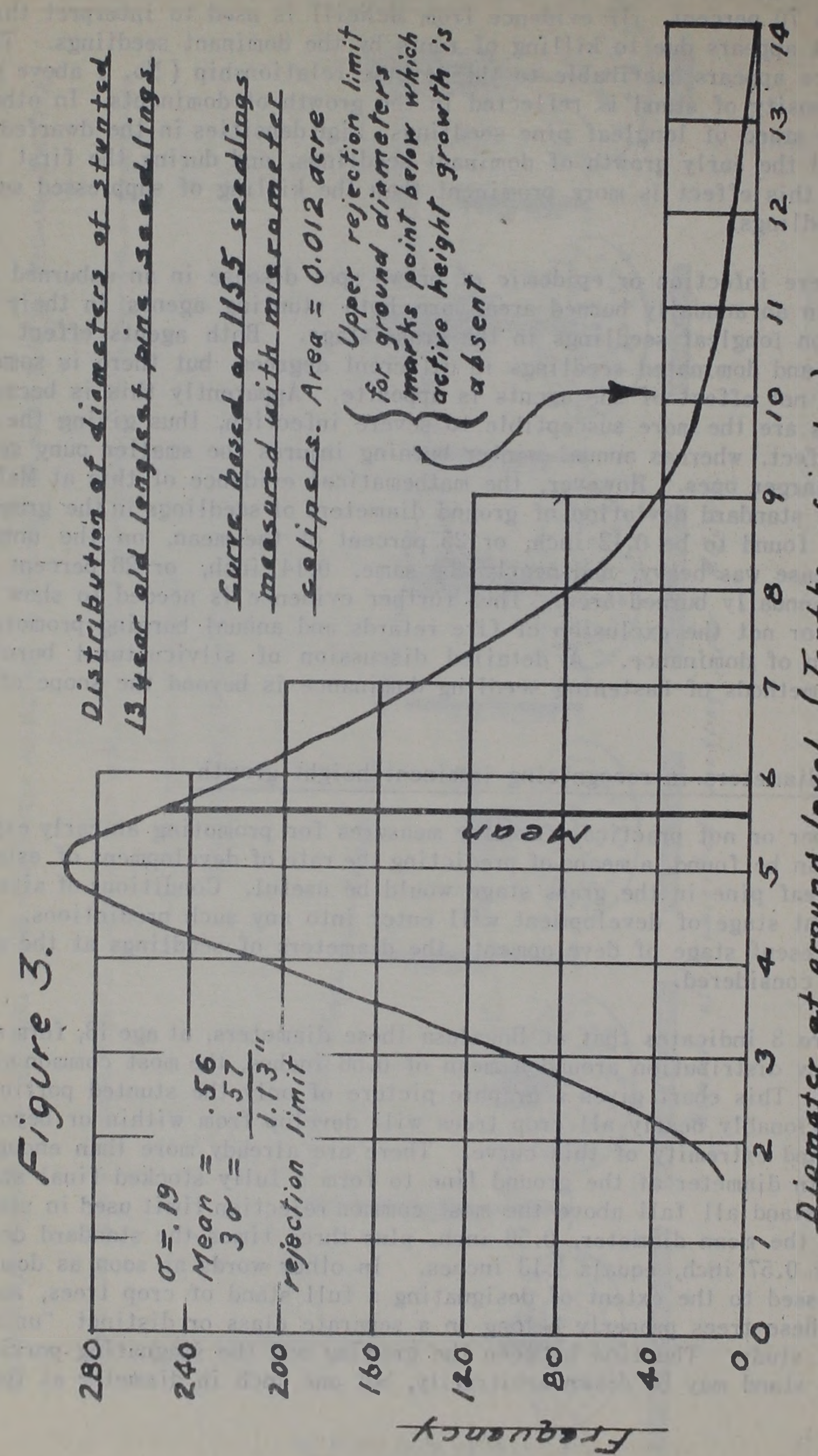


Figure 3.
Distribution of diameters of stunted
13 year old longleaf pine seedlings
Curve based on 1155 seedlings
measured with micrometer
calipers. Area = 0.012 acre
σ = .19
Mean = .56
3σ = .57
1.13"
rejection limit
Upper rejection limit
for ground diameters
marks point below which
active height growth is
absent
Mean
280
240
200
160
120
80
40
0
Frequency
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Diameter at ground level (Tenths of inches)

Even under the somewhat artificial conditions in a cultural experiment with 14-year old seedlings at Bogalusa, the relation between size attained and the initiation of active height growth still held. At 12 years of age, plots were thinned to an even spacing of one, five, and ten thousand trees per acre and the surrounding grass and vegetative competition removed. The denudation of the soil hastened development of the seedlings very appreciably. After two years the majority of these seedlings had developed from an average height of 1.7 inches to over six inches, and many exceeded one foot and were growing actively. In every case without exception trees over one foot high were over one inch in diameter at the ground.

Further evidence that one inch in ground diameter marks a turning point in the development of longleaf pine seedlings was obtained from simple measurements of the relation between diameter and height on three of four dozen seedlings. This was done on land burned over at irregular intervals at McNeill, Miss., with the results shown in figure 4. As the dots indicate, the great majority of seedlings reached one inch before starting active height growth. The age of these seedlings is unknown. About 90 seedlings known to be 8½ years old and untouched by fire were measured on an ungrazed plot nearby. The plotted heights and diameters of these seedlings all fell within the small shaded area and centered around diameter 0.44 and height 1.2 inches (marked x on the chart). Apparently these seedlings will have to double their size before active height growth can be expected.

A further check was made at Bogalusa by measuring the ground diameters of seedlings making normal growth. One hundred seedlings recently emerged from the grass stage, and ranging from 7 to 18 inches, averaged 1.3 inches in diameter at the ground. Only 5 trees were slightly less than 1 inch in diameter owing to sloughing off of bark. Ten trees between 4 and 5 feet high had ground diameters between 1.7 and 2.1 inches, averaging 1.8 inches.

A list of averages of measured ground diameters, with the number of trees calipered, follows:

Average diameter at the ground (inches)	Growing conditions	Number of seedlings calipered
	Age, 8½ years; McNeill, Miss.	
0.39	Unburned pasture	177
0.44	Unburned check	811
0.46	Burned pasture	29
0.53	Burned check	103
	Age, 4½ years; Urania, La.	
0.49	Burned before seed fall	131
0.71	Unburned	142
	General observations	
Under 1.0	No height growth regardless of age	-
1.0	Minimum development to start active height growth	-
	Age, 13 years; Bogalusa, La.	
1.1	Upper diameter limit of stunted stand (mean - 3 times standard deviation)	1,155
1.3	Seedlings emerge from the grass	100
1.8	Breast-high seedlings: 4-5 feet.	10

Apparently longleaf pine seedlings may become 1 inch in diameter at the ground, and some of them slightly larger, without growing actively in height, but, regardless of age, they never emerge from the grass stage and do not make the norma spurt in height until they attain a ground diameter of at least 1 inch.

Curiously enough, this point in the behavior of the seedlings has its count part in human development. Admittedly, in most respects trees and men are incompar able. Resemblance is so remote that analogies between them prove nothing. Yet it is most interesting to note that the adolescent spurt in human height growth has rec ly been correlated with size rather than age. Accelerated growth begins when a chi reaches a certain height, 50 inches for girls and 53 inches for boys, irrespective of age [7].

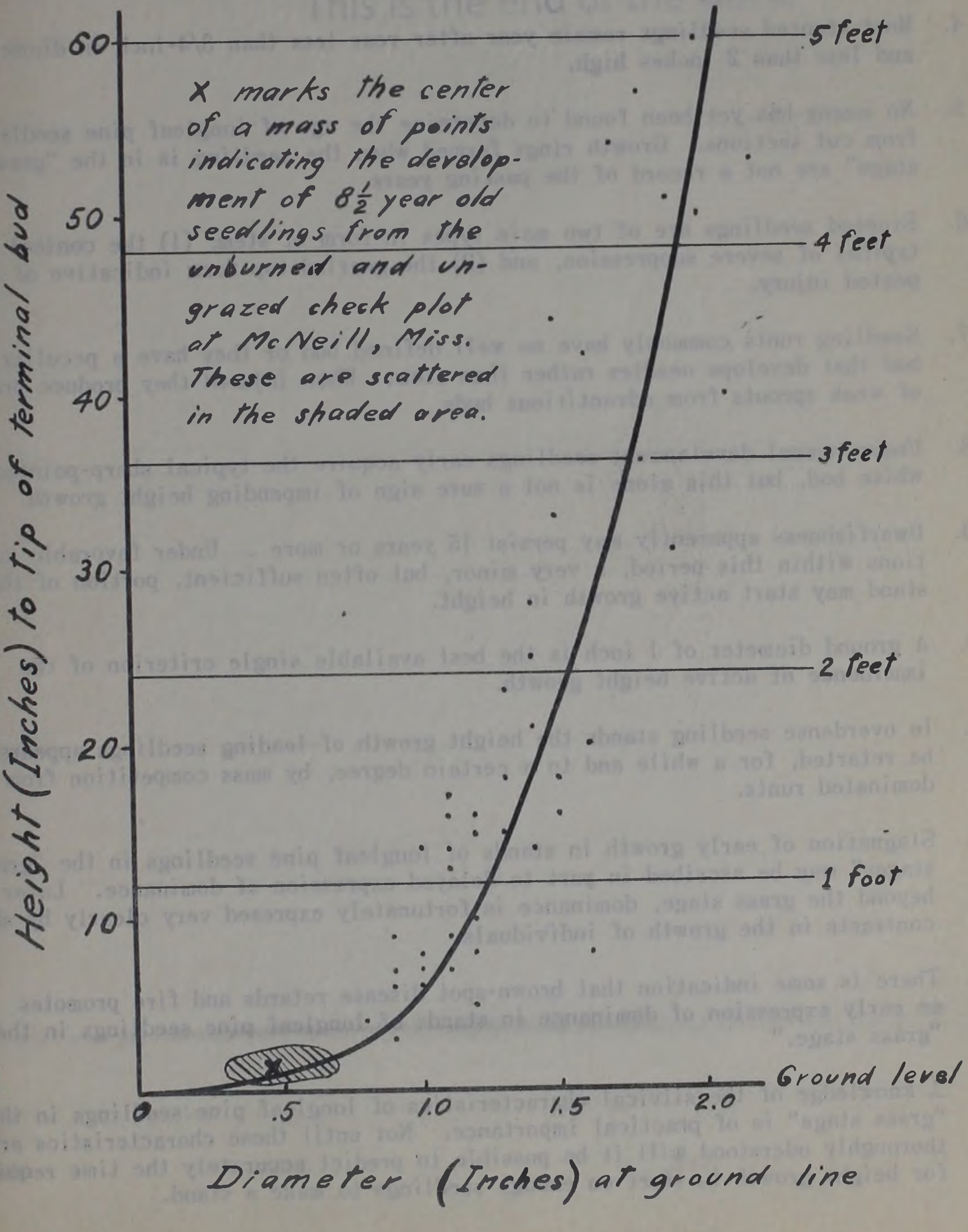
[7] Based on analysis of annual measurements of 2,500 school children, 6 to 14 years old, made during a period of 4 to 7 years by Dr. C. E. Palmer of U. S. Public Health Service and Johns Hopkins School of Hygiene and Public Health, and reported to the American Association of Anatomists in Philadelphia. Science News Letter, March 31, 1934.

Figure 4.

RELATION OF GROUND DIAMETERS TO HEIGHTS OF LONGLEAF PINE SEEDLINGS

Note that active height growth can not be expected before the seedlings reach one inch in diameter

Seedlings outside the shaded area are of unknown age



Summary

1. Though more difficult to control, the density of stand affects the developmer of seedlings as much as it does trees of sapling or pole size.

2. Overdense stands of longleaf pine seedlings (more than 200,000 per acre at Bogalusa in 1920) may follow a combination of favorable conditions, includin improvement of natural seedbeds as a result of fires.

3. Longleaf pine seedlings suffer from prolonged nanism in overdense stands, on poor sites, and where they are repeatedly and frequently injured by brown-spo disease or fire.

4. Most stunted seedlings remain year after year less than 3/4-inch in diameter and less than 2 inches high.

5. No means has yet been found to determine the age of longleaf pine seedlings from cut sections. Growth rings formed when the seedling is in the "grass stage" are not a record of the passing years.

6. Stunted seedlings are of two main types in form of stem: (1) the conical forr typical of severe suppression, and (2) the gnarled-top form indicative of repeated injury.

7. Seedling runts commonly have no well defined bud or they have a peculiar fla bud that develops needles rather than stem. When injured they produce profus of weak sprouts from adventitious buds.

8. Under normal development seedlings early acquire the typical sharp-pointed white bud, but this alone is not a sure sign of impending height growth.

9. Dwarfishness apparently may persist 15 years or more . Under favorable condi tions within this period, a very minor, but often sufficient, portion of the stand may start active growth in height.

10. A ground diameter of 1 inch is the best available single criterion of the imminence of active height growth.

11. In overdense seedling stands the height growth of leading seedlings appears to be retarted, for a while and to a certain degree, by mass competition from the dominated runts.

12. Stagnation of early growth in stands of longleaf pine seedlings in the "grass stages" may be ascribed in part to delayed expression of dominance. Later on beyond the grass stage, dominance is fortunately expresed very clearly by shar contrasts in the growth of individuals.

13. There is some indication that brown-spot disease retards and fire promotes an early expression of dominance in stands of longleaf pine seedlings in the "grass stage."

14. A knowledge of the silvical characteristics of longleaf pine seedlings in the "grass stage" is of practical importance. Not until these characteristics are thoroughly uderstood will it be possible to predict accurately the time requirec for height growth to start on enough seedlings to make a stand.